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8. Consequences of the lactational environment on behavioural problems of pigs after weaning

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Abstract

An important part of pig brain development takes place after birth and depends upon internal and environmental inputs. Therefore, the environment of the piglets during the lactational period may influence their cognitive and behavioural development, hence their predisposition to fight and to perform other forms of deleterious behaviours such as sustained belly nosing or tail biting. Such behaviours are of great concern to the pig industry for animal welfare and economic reasons. This chapter focusses specifically on predisposing factors during the postnatal period until weaning for the expression of fighting and other deleterious behaviours later in life. During that suckling period, the piglet acquires essential elements to develop a good immune status, proper gut microbiota, and high disease resilience for its future life. Health problems are a major risk factor for the occurrence of tail biting so that ensuring good colostrum intake and proper hygiene in the farrowing room might reduce deleterious behaviours in the long-term. Fighting behaviour is reduced by cross-fostering and socialisation before weaning whereas early-life competition for limited resources appears to increase subsequent aggressiveness. Therefore, any means allowing piglets from different litters to interact from the second week of age onward should be encouraged. Social stress, due to competition and cross-fostering, also stimulates the occurrence of other deleterious behaviours later in life and is highly dependent on litter size at birth. Therefore, the full consequences of large litters at birth should be evaluated in terms of health, welfare and performance over the whole life of pigs. Enriching the environment during lactation has diverse effects on fighting behaviour with no effect in most situations and a reduction, or even an increase, in some others. Similarly, it has diverse effects on tail biting and on manipulatory behaviours suggesting that the nature of the enrichment, the age, and the timing at which it is presented might greatly influence its impact on such deleterious behaviours. This chapter emphasizes that even though the environment in which post-weaned pigs are raised is of major importance for the expression of nefarious behaviours, the pre-weaning environment should also be optimized to reduce their likelihood.

Keywords: belly nosing, fighting behaviour, health, preweaning environment, socialisation, tail biting

8.1 Introduction

An important part of pig brain development takes place after birth and depends upon internal and environmental inputs. Therefore, nutritional deficit, poor health or scarcity of sensory stimuli during the lactational period may have long-term consequences on cognitive abilities and on behaviour of growing pigs and hence on their predisposition to fight and to perform other forms of damaging social behaviour. Severe fighting, non-aggressive biting and severe belly nosing are behavioural problems contributing to reduced welfare through distress and lesions that are likely to be painful and may become infected. Beyond these negative consequences, there are possible economic losses for the farmers due to lower growth performance and higher morbidity and mortality of the pigs.

Fighting is common in the context of dominance hierarchy formation and occurs mostly in the first hours after creating a new social group (Meese and Ewbank, 1973). It can also occur, to a lesser extent, in stable groups when animals compete for limited resources or when some pigs challenge the established hierarchical order (Meese and Ewbank, 1973; Parois *et al*., 2017; Peden *et al*., 2018). Fights consist of a series of pushes, head-knocks and bites, the latter two being preferentially targeted at the head and the shoulders (the front third of the body) (Fraser and Rushen, 1987; McGlone, 1985; Turner *et al*., 2006). Another form of damaging social behaviour is non-aggressive biting, which is largely unrelated to hierarchy formation and resource competition. Non-aggressive biting, such as tail biting, occurs mainly, though not exclusively, in barren environments where pigs cannot satisfy their behavioural needs in terms of play, exploration and foraging (D'Eath *et al*., 2014; EFSA, 2007; Valros and Heinonen, 2015). Its occurrence is also favoured by other external or internal factors, such as high animal density, low access to feed or water, a suboptimal climate or health disorders (D'Eath *et al*., 2014; EFSA, 2007; Valros and Heinonen, 2015). Non-aggressive biting is often targeted at the tail, but ears, legs or other parts of the body can also be the subject of biting. Other oral behaviours directed at pen-mates such as massaging, nibbling, chewing or sucking other pigs can also induce lesions when they are performed repeatedly (Algers, 1984). Massaging (also termed belly nosing) is common in pigs that are weaned at a young age and is considered to be a redirection of the mammary gland massaging that occurs after nursing (Gonyou *et al*., 1998; Van Putten and Dammers, 1976). The objective of the present chapter is to evaluate the consequences of the lactational environment on the expression of behavioural problems encountered in growing pigs after weaning.

8.2 Consequences of neonatal immune development and health

In pigs, it is well-known that the perinatal period is very important for long-term health resilience (Pluske, 2016). A suboptimal development of the immune system during lactation, for example due to insufficient colostrum intake (Declerck *et al*., 2016; Devillers *et al*., 2011), has a long-term effect on health and growth. Furthermore, recent studies indicate that the current health status of pigs is linked to an increased risk for developing deleterious behaviours (Munsterhjelm *et al*., 2017, 2019). However, as far as we know, there is no direct evidence for a link between piglet health during the lactational period

and behavioural problems in pigs at a later age. Some evidence of a long-term effect of sanitary conditions on biting behaviour was recently presented by Van der Meer *et al.* (2017), but in this case the different sanitary conditions, including vaccination and housing hygiene, were only introduced after weaning. There are, however, many studies in laboratory animals indicating the importance of early health challenges on brain, and consequently behavioural development. The behaviour of adolescent as well as adult rodents, including emotional (especially anxiety-like) behaviour, stress responses and reaction to a painful stimulus (Andre *et al.*, 2014; Dinel *et al.*, 2014; Walker *et al.*, 2009; Yan and Kentner, 2017) has been shown to be altered by a neonatal immune challenge. It was suggested that the underlying physiological changes following neonatal immune challenge include alterations in the hypothalamo-pituitary-adrenal axis, the expression of different genes, and the cytokine responses. We thus suggest that such a link probably does exist also in the pig, and that there is a need for further studies on this area.

Another potential mechanistic link between neonatal health and later behaviour was suggested by Brunberg *et al.* (2016): namely the microbiota-gut-brain axis. There is some evidence of an association between the gut microbiota and the common behavioural problem of feather pecking in hens (Meyer *et al.*, 2012) but, to the best of our knowledge, there are no comparable studies in pigs. The early neonatal period is important for the development of the gut microbiota. It has been shown that the intestinal microbiota can be altered for a prolonged period by antibiotic treatments in neonatal pigs, and also to a limited extent by stress due to handling (Schokker *et al.*, 2015). There is also some evidence that probiotics, either ingested by the sow during gestation and lactation or by piglets postnatally, can have positive long-term effects on piglet health, as shown by a reduced risk for post-weaning diarrhoea (Hayakawa *et al.*, 2016). It is interesting to note that gastrointestinal disorders during the nursery phase are often reported by producers to be a risk factor for tail biting (Valros, personal communication).

In summary, we conclude that the basis for a good immune status, proper gut microbiota, and high disease resilience in pigs is set already during the lactational period. Thus, by ensuring good colostrum intake and proper hygiene in the farrowing room, it might be possible to positively affect pig behaviour in the long-term.

8.3 Consequences of social stress due to competition for teats or other resources

Colostrum and milk are essential to piglet survival and growth. Piglets may compete at the udder to gain access to a functional teat and, if possible, to the best one (Prunier *et al.*, 2020). A larger litter size increases the level of competition. In addition, piglets that use teats in the middle of the udder have potentially more competitors for the teats than those that use the anterior or posterior teats.

8.3.1 Fighting behaviour

There is evidence that aggressiveness after weaning may, at least in part, result from a need to strongly compete for milk during early life. For example, D'Eath *et al.* (2004) showed that a large litter size leads to heightened aggressiveness when faced with an unfamiliar intruder in the home pen 2-3 weeks after weaning. This effect of litter size may be very context specific as Chaloupková *et al.* (2007) found that litter size did not influence the frequency of agonistic behaviours in newly weaned piglets mixed into a new social group in a new pen. Subsequently, Skok *et al.* (2014) showed that piglets that had suckled from middle teats, and hence had competed with littermates to their left and right, were involved in more aggressive interactions with unfamiliar pigs post-weaning than those that had suckled from other parts of the udder. This effect did not seem to be related to live weight at weaning, which was similar in piglets suckling anterior and middle teats.

Sibling competition is likely to occur in other contexts that affect well-being, such as access to a warm resting area. While there has been little work to quantify how much biting occurs to access a nest or creep area of a fixed size, it most likely increases with litter size. This early-life competition probably has similar effects on later behavioural development as that resulting from competition for access to teats.

Taken together, these studies suggest that social competition experienced by piglets during lactation increases aggressive biting behaviour after weaning. Future work should confirm whether the effect of competition leads to a general increase in post-weaning aggressiveness or to an increase in aggressiveness only under specific circumstances. Furthermore, the effect of competition for resources other than milk, such as access to a lying area, should be studied.

8.3.2 Other deleterious behaviours

To the best of our knowledge, only Ursinus *et al.* (2014) examined the relationship between litter size during lactation and the level of tail chewing and biting later on. Animals were housed in single-sex pens and only pens of females were observed. They showed that females expressing a relatively high level of tail chewing and biting were more likely to originate from larger litters than females with a relatively low level of tail chewing and biting. However, this result was dependent on the rearing environment, since it occurred only when pigs were housed in an environment enriched with jute sacks during lactation and after weaning.

Therefore, non-aggressive biting behaviour may be increased in piglets originating from large litters in specific environments, but more data are needed to examine this relationship.

8.4 Consequences of socialisation of piglets by contact with piglets from other litters

Under commercial conditions, pigs usually first encounter unfamiliar pigs at weaning at around 4 weeks of age whereas piglets from free-range environments interact with piglets from other litters from the second postnatal week, even though they show a preference for littermates (Jensen and Redbo, 1987; Newberry and Woodgush, 1986; Petersen *et al.*, 1989). Pre-weaning integration of adjacent litters leads to an increase in aggression shortly after the event but when pigs are regrouped later in life, at a period when aggression is much more severe, the number of skin lesions is decreased compared with piglets without experience of pre-weaning integration (e.g. Camerlink *et al.*, 2018). Therefore, aggressive interactions do occur but at a relatively low level when early-life integration of piglets is applied under commercially realistic conditions. An early-life window of greater tolerance of unfamiliar conspecifics exists and could be exploited to reduce fighting behaviour in older pigs. Lower occurrence of other behavioural problems is less likely but deserves to be evaluated.

8.4.1 Fighting behaviour

Pre-weaning socialisation can be achieved by allowing piglets, but not sows, from adjacent farrowing pens to mix (Camerlink *et al.*, 2018), or by using a multi-suckling system in which multiple sows and litters are allowed to integrate (Van Nieuwamerongen *et al.*, 2015). Pre-weaning socialisation reduces fighting when piglets are later mixed at weaning. This is assumed to operate through an improvement in social skills, but the exact mechanism is not understood. Studies unanimously find a reduction in the frequency and/or the duration of biting behaviour or in the number of skin lesions at post-weaning regrouping in pigs that have experienced socialisation in early life either through interacting with an adjacent litter in a conventional farrowing house or in a multi-sucking system (D'Eath, 2005; Kanaan *et al.*, 2008; Kutzer *et al.*, 2009; Salazar *et al.*, 2018; Van Nieuwamerongen *et al.*, 2015; Weary *et al.*, 1999). Resident-intruder tests, in which a smaller intruder is introduced into the pen of a resident pig, have been used to understand the manner in which socialisation reduces post-weaning aggression. D'Eath (2005) reported that socialised pigs were quicker to attack an intruder while Camerlink *et al.* (2018) showed that socialised pigs took longer to interact with an intruder but, once contact had been made, attacked the intruder more rapidly. This might indicate that socialisation increases aggressiveness rather than reduces it. However, Camerlink *et al.* (2018) interpreted this as evidence of greater assessment skills because a longer period of opponent assessment followed by rapid attack was previously found in pigs that had more fighting experience (Camerlink *et al.*, 2017). This altered aggressive strategy appears to lead to an overall reduction in fighting when pigs later experience the dynamic situation of group mixing. D'Eath (2005) confirmed that socialised pigs show less evidence of prolonged bullying after regrouping. Taken together, the evidence would suggest that socialised pigs invest more effort in assessing an opponent and are no less aggressive, but are better able to efficiently establish dominance relationships which reduces the overall costs of aggressive interactions.

Social play is believed to be important in the development of later aggressive strategies. Indeed, female (but not male) piglets which engaged in the most play fighting subsequently attacked an intruder pig more quickly (Weller *et al.*, 2019). It is assumed that socialisation enhances social skills by encouraging social play, and in particular play fighting. However, Weller *et al.* (2019) found that social play was not enhanced by socialisation, suggesting that the benefits of social play operate through a different mechanism. It is possible that the benefit of socialisation derives both from early-life contact with unfamiliar piglets and also from being exposed to a more complex and larger physical environment. Indeed, several of the studies that demonstrated a reduction in aggression from socialisation provided greater environmental complexity for socialised piglets (Hillmann *et al.*, 2003; Weary *et al.*, 1999). However, the works of Wattanakul *et al.* (1997), Kutzer *et al.* (2009) and Camerlink *et al.* (2018) showed that removing the division between adjacent farrowing pens reduced post-weaning aggression and skin injuries, even though the floor space per piglet and level of enrichment of the environment remained the same. This indicates that socialisation in itself can reduce subsequent aggression independently of, or in combination with, environmental enrichment.

Altogether, these studies indicate that socializing piglets during lactation, by allowing them to interact with piglets from other litters, reduces aggressive biting after weaning. Pigs are often regrouped several times after weaning and, at present, it is unknown whether the benefits of socialisation are evident only during mixing at weaning or persist into later regrouping episodes. Camerlink *et al.* (2018) found no effect of pre-weaning socialisation on the number of skin lesions from chronic aggression 3 weeks after social groups had been formed, suggesting that its benefits may be transient or limited to aggression with unfamiliar pigs.

8.4.2 Other deleterious behaviours

Consequences of socialisation on other behavioural problems have received much less attention. Klein *et al.* (2016) compared control piglets reared in conventional farrowing pens with piglets allowed to socialize by opening 'piglet-doors' giving access to a walkway, starting at 10 days after parturition. Although tail biting occurred in all groups, a higher percentage of pigs from the early-socialised groups had intact tails at day 100 of the fattening period, and their tails were significantly longer. Therefore, socialisation of piglets during lactation may also reduce propensity for non-aggressive biting later on.

8.5 Consequences of cross-fostering

Litter size has increased to such an extent over the past decades that the number of live born piglets often exceeds the number of functional teats and solutions have to be found to manage the surplus of piglets. Among them, cross-fostering and fostering to a nurse sow are common practices in commercial pig husbandry (Baxter *et al.*, 2013). If performed correctly, cross-fostering increases the chances of survival of piglets. Cross-fostering should not be performed too early after birth as piglets need to ingest colostrum, but it should not be delayed beyond 2 days since aggression is more intense and pre-weaning

mortality is higher (Straw *et al*., 1998) as piglets get older at fostering. The piglets that are fostered may suffer from hunger and chilling during the process of acceptance, while all the piglets in the litter may suffer from social stress. There are reports of long-term detrimental consequences of cross-fostering on survival, growth, behaviour, reproductive success and immunity (Baxter *et al*., 2013). Therefore, long-term effects of this practice on aggressive and non-aggressive behaviours are expected.

8.5.1 Fighting behaviour

Cross-fostering would appear to create similar changes in aggressive behaviour post-weaning to those described earlier for the effect of socialising litters (see previous section on consequences of socialisation). This is perhaps unsurprising since both cross-fostering and socialisation provide early-life experience of interacting with unfamiliar piglets at a young age. However, the context and age of cross-fostering is different as it usually involves the movement of alien piglets into an established litter and is performed at an age when wild piglets would normally not have ventured far from the nest and met unfamiliar piglets (D'Eath and Turner, 2009). Both Giroux *et al*. (2000) and Scheffler *et al*. (2016) provide evidence that cross-fostering reduces the amount of fighting and number of injuries in the short term following regrouping after weaning. The benefit may be transient or limited to interactions with unfamiliar pigs as Giroux *et al*. (2000) and Diaz *et al*. (2018) found no long-term reduction in lesions several weeks after regrouping. If this transient or context-specific benefit of cross-fostering is true, it may again parallel the same pattern described for socialisation.

Altogether, the current evidence suggests that cross-fostering may reduce aggressive behaviour and the amount of skin lesions, but with a decreasing influence over time, or that the benefit is limited to interactions with unfamiliar pigs. As for socialisation, the specific mechanism by which cross-fostered piglets gain enhanced social skills remains to be examined.

8.5.2 Other deleterious behaviours

A higher incidence of tail biting was observed in farms where cross-fostering was practiced compared with farms with no cross-fostering (Moinard *et al*., 2003). However, from these epidemiological data, it cannot be elucidated whether cross-fostering contributed directly to later likelihood of tail biting or whether this association was related to a common causal factor (for example, herd size or litter size increasing the occurrence of cross-fostering). More recently, an observational study including more than 1000 piglets from a commercial farm showed that the presence of tail lesions was not influenced by the occurrence of either early or late cross-fostering (Diaz *et al*., 2018). However, cross-fostered pigs, regardless of the age at fostering, were more at risk of death and euthanasia, with severe tail lesions being one of the reasons for euthanasia (Diaz *et al*., 2018). Based on the evidence of only these two studies, it is likely that cross-fostering exacerbates non-aggressive biting after weaning.

8.6 Consequences of a very young age at separation from the dam

In natural conditions, weaning of piglets is a very progressive phenomenon lasting for several weeks and ending at about 17 weeks of lactation (Jensen and Recen, 1989). Contrarily, in most commercial pig farms, weaning is abrupt and occurs between 3 and 5 weeks of age. Such an abrupt weaning is highly stressful for the animals, as shown by activation of the adrenal axis and changes in behaviour (Colson *et al.*, 2006, 2012), which are greater as weaning takes place earlier. Therefore, potential consequences of weaning on the behaviour of pigs during the post-weaning and fattening periods could differ according to the age at weaning. An extreme situation arises with 'artificial rearing' of piglets starting shortly after birth, as described in Chapter 3 (Baxter *et al.*, 2020). This is performed when sows have more piglets than teats and cross-fostering cannot be performed (Baxter *et al.*, 2013). In this situation, piglets are allowed to suck colostrum from the dam and are then transferred to a rearing pen, where they drink milk in a cup. This gives no opportunity to suckle even though the motivation to do so is high (Frei *et al.*, 2018; Noyes, 1976).

8.6.1 Fighting behaviour

Pigs weaned at a conventional age of 30 days showed a similar amount of fighting behaviour to those weaned at 10 days, when fighting behaviour was evaluated between 40 and 150 days of age (Hohenshell *et al.*, 2000). In agreement with this, the frequency of aggressive behaviours measured at 42 days of age did not differ between pigs weaned at 7, 14 or 28 days of age (Worobec *et al.*, 1999). Although neither of these studies examined the effect of weaning age on aggression performed when regrouped at weaning itself, when aggression may be very common, they suggest that early weaning does not influence aggressive behaviour in the long term.

8.6.2 Other deleterious behaviours

Artificial rearing of piglets that are separated from the sow between 3 and 6 days of age results in high levels of belly nosing that lasts until at least 50 days of age (Hosp *et al.*, 2014; Rzezniczek *et al.*, 2015). Whether this very early separation from the dam leads to a greater propensity for tail biting has not been evaluated. However, it is very likely, since the frequencies of tail biting and belly nosing behaviours are highly correlated in fattening pigs (Brunberg *et al.*, 2011; Edwards, 2003).

Pigs weaned at 7 or 14 days of age showed a higher frequency of massaging penmates at 42 days of age than did pigs weaned at 28 days of age, but there was no effect on the occurrence of nosing or chewing penmates (Worobec *et al.*, 1999). When comparing pigs weaned at approximately 10 or 30 days of age, Hohenshell *et al.* (2000) found almost a 3-fold increase in manipulatory behaviours (nosing + biting + pushing + suckling part of another pig's body) at 40 days of age in early weaned pigs. Thereafter, manipulatory behaviours decreased in early weaned pigs and became similar in both groups of pigs at 65, 102, 137, and 165 days. In another study comparing pigs weaned at 3 and 6 weeks of

age, more massaging + nibbling + sucking pigs was found in the pigs weaned at 3 weeks and the difference was marked from 3 to 8 weeks of age (Algers, 1984). In parallel, the proportion of litters with sow injuries at the teats or at the preputium/vulva was greater in the earlier-weaned group even though the difference was significant only for teat lesions observed between 3 and 5 weeks of age. No effect was found for tail lesions of pen mates. Comparing pigs weaned at 4 and 6 weeks, Boe (1993) found a higher frequency of massaging and sucking pen mates at the beginning of the fattening period in pigs weaned at the youngest age, but no increase in tail biting or tail lesions.

Therefore, early weaning stimulates, at least transiently, massaging and/or chewing of pen mates, with the risk of provoking damage if it is persistent. However, available data suggest that age at weaning has no clear influence on tail biting in growing pigs.

8.7 Consequences of the housing environment

In most conventional farms, the environment provided to piglets during lactation is poor in terms of space and complexity, does not fulfil their needs for exploration, and places constraints on the opportunities for object manipulation, locomotion and social play (Martin *et al.*, 2015). This may result in behavioural and physiological problems, with potential long-term consequences on the ability of pigs to cope with their rearing conditions, as well as on their social skills and abilities to resolve social conflicts (De Jonge *et al.*, 1996). The environment in lactational pens includes numerous features that act simultaneously on piglets making it difficult to isolate individual effects. Among these features, restricted space and lack of enrichment material are probably the most important. Construction features like bars of crates may hinder vision and movement, and thus proper communication between piglets, leading to increased agonistic behaviours (Lammers and Schouten, 1985). Other environmental features, such as continuous noise over certain thresholds (>85 dB), may also be important (Algers and Jensen, 1991).

Besides experiments comparing enriched and poor environment throughout the life of piglets, other studies have been set up to evaluate the influence of the early environment *per se* on the behaviour of pigs observed during the subsequent post-weaning or fattening periods (Table 8.1).

8.7.1 Fighting behaviour

The greatest variation in pre-weaning environment is created when comparing piglets born indoors with those born outdoors. An outdoor environment provides more space, more rooting opportunities and early-life socialization with other litters. To our knowledge, only two studies have compared the post-weaning fighting behaviour of pigs born indoors versus outdoors, with conflicting results. Webster and Dawkins (2000) found no effect of the pre-weaning environment on fighting behaviour observed just after weaning, as well as at 1, 2 or 8 weeks after weaning. However, with a larger ethogram, Cox and Cooper (2001) described less fighting behaviour during the first 2 days after weaning in pigs born outdoors. Whether this was caused by early life socialization (see previous

Table 8.1. Influence of the lactational (preW) environment on the behaviour of pigs during the post-weaning (postW) or fattening periods (modified from Prunier et al.*, 2020).*[1]

Reference	Housing during lactation	Age at weaning in days	Housing during the postW period	Housing during fattening	Effect of enrichment on tail biting or manipulatory behaviours (nosing, chewing, massaging)	Effect of enrichment on fighting behaviour
Webster and Dawkins, 2000	Outdoors (arks with straw) vs indoors (concrete floor + straw, farrowing crate)	21-28	Straw-bedded, open-fronted pens with gale-breakers	Straw-bedded, open-fronted pens with gale-breakers		No effect at 1, 2 and 8 weeks postW
Cox and Cooper, 2001	Outdoors (arks with straw) vs indoors (concrete floor + straw, farrowing crate)	24	Kennel with concrete floor + straw, outdoor area	NA	No effect during the 2 days postW	**Less fighting behaviour during the 2 postW days**
Van de Weerd *et al*., 2005	Rooting box (chopped straw, hay, shredded paper or compost in alternation) vs liquid dispenser vs straw bedding vs none	28	Partly slatted floor	Straw bedded floor vs partly slatted floor with a plastic toy from 70 days of age	In straw bedded pen: no effect of the preW environment on behaviour and tail lesions during fattening. ***In partly slatted pen: higher level of manipulatory behaviours in pigs from liquid dispenser than from no enrichment*** but no effect on tail lesions during fattening	NA
Chaloupková *et al*., 2007	Enriched pen (straw, more space, no crate) vs enriched crate (straw) vs conventional crate (no straw)	28	Straw bedding	Slatted floor from 84 days of age	NA	No effect shortly postW. **Fewer agonistic interactions during a food competition test at 3 and 6 months of age in pigs from the enriched pens compared to enriched and conventional crates**
Vanheukelom *et al.*, 2011	Peat in a tray vs no peat	28	Peat in a tray vs no peat	Peat in a tray vs no peat	No effect during the postW and fattening periods regardless of postW environment	No effect during the postW and fattening periods regardless of postW environment

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Table 8.1. Continued.

Reference	Housing during lactation	Age at weaning in days	Housing during the postW period	Housing during fattening	Effect of enrichment on tail biting or manipulatory behaviours (nosing, chewing, massaging)	Effect of enrichment on fighting behaviour
Statham *et al*., 2011	Straw (1 kg twice a week) vs wood shavings (0.5 kg/day)	25	Straw-bedded floor	Straw-bedded floor	No effect during the postW and fattening periods on behaviour and tail biting outbreaks	No effect during the postW and fattening periods
Telkänranta *et al*., 2014	High (sisal ropes + a plastic ball + newspaper + wood shavings) vs low (a plastic ball + wood shavings) level of enrichment	21-25	Sisal ropes + a plastic ball + newspaper + wood shavings	NA	**Lower prevalence of severe tail damage at 9 weeks of age in pigs from high enrichment pens** but no effect on manipulation of piglets	NA
Martin *et al*., 2015	Enriched (more space, no crate, more straw) vs conventional (less space, crate, little straw)	27	Deep straw bedding	NA	NA	No effect on fighting behaviour but ***more lesions at 3 days postW in pigs from enriched pens***
Day *et al*., 2002	Straw vs no straw			None vs minimal, vs substantial vs deep level of straw	No effect on tail biting	No effect on fighting behaviour, excluding biting ***More biting when fatteners are housed without straw***
Bolhuis *et al*., 2006	Straw vs no straw			Straw vs no straw	No effect on manipulatory (belly nosing + manipulating ears, tail, other part of the body) behaviours in both current fattening environments	No effect on fighting behaviour in both current fattening environments

[1] Lack of effects are indicated in plain characters, positive effects in bold characters and negative effects in bold and italic characters. NA = not applicable.

section on consequences of socialisation), environmental enrichment or a combination of the two is unknown.

Other studies have compared different indoor farrowing environments and reported that physical environmental enrichment does not reduce fighting behaviour (Chaloupková *et al*., 2007; Martin *et al*., 2015; Statham *et al*., 2011; Vanheukelom *et al*., 2011). The only exception to this outcome was that pigs from enriched farrowing pens were less aggressive in resource competition tests at 3 and 6 months of age compared to pigs raised in conventional or enriched farrowing crate environments, even though there were no effects on aggression immediately after weaning. The work of Martin *et al*. (2015) showed that enrichment (280% more space plus fresh long-stemmed straw) increased the number of skin lesions in the 3 days immediately post-weaning, although it did not affect the longer-term expression of aggressive behaviour from 28 to 56 days of age. Lastly, work by Day *et al*. (2002) suggests negative effects of reducing the level of enrichment from one age to the other. Indeed, they showed an increase in post-weaning biting in pigs housed in pens without straw compared to pens with straw only if pigs had experienced straw in the farrowing environment.

8.7.2 Other deleterious behaviours

Moinard *et al*. (2003) compared commercial farms having had an episode of tail biting during the previous 6 months with farms that had no episode of tail biting. They suggested a link between the degree of enrichment during lactation and the incidence of tail biting. This was based on the observation that farms without tail biting had a greater occurrence of daily renewal of straw in the farrowing pens. However, this effect may have been confounded with the more frequent use of straw during the later stages of pig production in farms without tail biting. Cox and Cooper (2001) found no difference between indoor and outdoor pre-weaning environments on the incidence of tail biting or belly nosing performed by piglets during the first 2 days after weaning. Van de Weerd *et al*. (2005) compared different enrichment materials provided for 4 weeks either during lactation or during the immediate post-weaning period. During fattening (between 10 weeks of age and slaughter at around 90 kg live weight), pigs were reared on partly slatted floors with a minimum legal amount of enrichment (only a Bite Rite plastic toy) or on straw bedding. The lactational environment had no influence on tail biting, belly nosing or manipulation of other pigs (nosing or chewing any part of another pig) during fattening, in contrast to effects of the current environment whereby damaging behaviours were reduced by straw bedding. Similarly, Statham *et al*. (2011) reported no effect of adding straw on the floor of farrowing pens on outbreaks of tail biting, tail-oriented behaviours (biting, chewing, nosing) or belly nosing frequency in pigs subsequently reared on solid concrete floors with straw. Furthermore, Vanheukelom *et al*. (2011) saw no effect of enriching the pre-weaning environment with peat on manipulatory behaviours (chewing and non-violent biting any part of a pen mate) during the post-weaning and fattening periods. Contrarily, Telkänranta *et al*. (2014) observed a lower prevalence of severe tail damage at 9 weeks of age (10 vs 32%) in pigs subjected to a higher level of enrichment (sisal ropes + plastic ball + newspaper + wood shavings vs plastic ball + wood shavings) during lactation, when all pigs were reared in an identically-enriched environment after

weaning (sisal ropes + plastic chewing toy + wood shavings). However, the frequency of penmate manipulation, defined as touching any part of the body, was not influenced by the lactational environment.

When comparing pigs housed with or without straw throughout the lactation and post-weaning periods, Day *et al.* (2002) reported no significant influence of the early environment on tail biting by fattening pigs, whereas the presence of straw in their current environment reduced tail biting. Similarly, Bolhuis *et al.* (2006) did not find any influence of previous experience with straw during lactation and the post-weaning period on manipulatory (belly nosing + manipulating ears, tail, other parts of the body) behaviours in fatteners, whereas the presence of straw in the current environment reduced these behaviours.

As is the case for fighting behaviour, physically enriching the environment during lactation had diverse effects on tail biting and manipulatory behaviours, suggesting that the nature of the enrichment and the age at which it is presented might greatly affect its impact on deleterious behaviours. For example, it is possible that the presence of enrichment during lactation followed by its removal later on increases the expression of such behaviours due to a negative effect of losing the enrichment.

8.8 Conclusions

With regard to fighting behaviour, cross-fostering and socialization during lactation were shown to reduce its occurrence later on (Figure 8.1) while early-life competition for limited resources appears to increase subsequent aggressiveness. The practical consequence of these findings is that any means to allow piglets from different litters to interact with each other from the second week of age should be encouraged. Social stress, due to competition and cross-fostering, stimulates the occurrence of other deleterious behaviours later in life. All these factors in lactation are highly dependent on litter size at

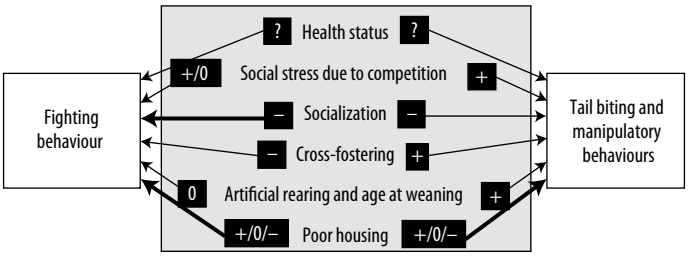

Figure 8.1. Summary of the effects of the lactational environment on the occurrence of fighting and other deleterious behaviours later in life. When at least five studies are available, the arrows are drawn with a thick line. Signs above the arrows indicate that there is at least one study showing that the considered factor increases (+), has no effect (0) or decreases (–) the occurrence of biting.

birth. Therefore, the full consequences of large litters at birth should be evaluated in terms of health, welfare and performance over the whole life of pigs in order to obtain a fuller assessment of the advantages and drawbacks of a high litter size. There may well be a certain threshold in litter size above which well-being and productivity may be impaired with our current sows and management systems. Furthermore, proper colostrum intake, as well as neonatal health, has long-term effects on pig health status, which, in turn is likely to affect the occurrence of deleterious behaviour.

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